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Bird Communities on Recently-logged and Mature Non-Industrial Private Forestlands in Virginia

Todd S. Fredericksen[1]

School of Natural Sciences and Mathematics
Ferrum College
Ferrum, Virginia 24088

ABSTRACT

Most studies of bird community responses to logging in the eastern United States have occurred on government or industrial forestlands. Non-industrial private forestlands (NIPFs), however, represent the single largest forestland ownership category in the nation and the largest source of timber, particularly in eastern states. This study compares bird species abundance, richness, and composition on recently harvested NIPF stands with mature forest stands over three years during the early breeding season and peak spring migration in Virginia. A total of 79 bird species was observed on the study sites, 76 of which were observed on recently logged stands and 37 on control stands. Logged stands had approximately twice the mean bird abundance and 50% higher species richness, on average, than that of mature forest stands. Bird species abundance was negatively correlated with overstory (>10 m) tree cover and midstory (2-10 m) tree cover and positively correlated with herbaceous layer cover (<0.5 m) and the amount of large woody debris. Bird species abundance was not significantly correlated with shrub cover (0.5-2 m) or the abundance of snags. Relationships for species richness were similar except that species richness was not significantly correlated with overstory cover. Differences in species composition were evident among bird communities on logged and mature forest stands and were also affected by the intensity of logging.

Key words: biodiversity, forest management, logging, timber harvesting.

INTRODUCTION

Timber harvesting, often referred to as logging, can have significant impacts on wildlife species. Each species of wildlife has specific habitat requirements for food, water, cover, and nesting sites, and habitat conditions may be changed by timber harvesting. For example, logging will decrease the amount of overstory tree cover, but typically increases understory ground cover, understory food sources, and the amount of woody debris on the forest floor (Fredericksen et al., 2000; Brawn et al., 2001).

The response of birds to logging is of particular interest to many conservation biologists and natural historians. Bird species are useful indicators of habitat change (Balda, 1975). In addition, populations of many bird species have experienced steep declines in recent decades. There are particularly strong concerns about Neotropical migrants that breed in North American forests (Robbins et al., 1989; Peterjohn et al., 1995) and whether logging may negatively affect forest interior bird species, particularly those in already fragmented landscapes (Robinson & Robinson, 1999). On the other hand, many bird species that require early successional forest habitat are also in decline (Brawn et al., 2001; Dettmers, 2003; Sauer et al., 2005).

Results of studies exploring the impacts of logging and other silvicultural treatments have been mixed and highly species-specific (Sallabanks & Arnett, 2005). Most of our knowledge of how birds respond to timber harvesting comes from research on industrial forestlands or government-owned forestland. Much less is known about how birds and other wildlife species respond to logging on non-industrial private forestlands (NIPFs), which comprise the majority of all forestland in the eastern United States (Birch, 1996) and from which the majority of timber is harvested in the United States (Best & Wayburn, 2001). These properties are often small in size and are imbedded within fragmented landscapes (Best & Wayburn, 2001; Butler &

[1]email: tfredericksen@ferrum.edu

Leatherberry, 2004). NIPFs are diverse and include forest stands within residential properties, farms, and hunting club lands.

As in most eastern states, the majority of all forestland in Virginia is owned by non-industrial forest landowners (Thompson & Johnson, 1996). In Virginia, the mean size of these forest tracts is 90 ha, but it is highly skewed towards small tracts, with 62% being less than 40 ha (Thompson & Johnson, 1996). This report describes the results of a three-year study to determine the impacts of logging and logging intensity on the early breeding season/spring migration abundance, species richness, and species composition of bird species at the interface between the southern Blue Ridge and Upper Piedmont physiographic provinces of Virginia. Bird species abundance and richness were also correlated with habitat variables including vegetation cover at different levels within the forest, coarse woody debris, and snags.

METHODS

Study Sites

A total of 18 forest stands were identified in each year of the study with harvest intensities ranging from no harvesting (100% of original overstory cover) to clearcutting (0% overstory cover) (Table 1). In 2004, eight recently-harvested stands (harvested within the past two years) and 10 mature forest stands were used in the study. In 2005 and 2006, there were nine harvested stands and nine mature forest stands that had no recent history of logging. Most of the same stands were used in all three years of the study. Care was taken to make sure that the forest stands were similar with respect to pre-harvest stand composition. Stands were dominated by naturally-regenerated hardwood tree species with some scattered White Pine (*Pinus strobus*) and Virginia Pine (*Pinus virginiana*). They were similar in size (12-40 ha) and landscape matrix (percentage of farms, fields, urban development, and forest).

Field Sampling

Bird species richness and abundance were estimated using point counts with a 40-m radius. There were four survey points in each stand, with each point separated by 100 m. Points were located systematically along a transect approximately through the center of each stand. All birds heard or seen within the point count area were recorded and identified to species. Counts were conducted from 0600-1000 h, and 2-4 stands were sampled each day. Point counts were not made during periods of rain or windy conditions. All points on each site were sampled twice between late-April and mid-May each year from 2004-2006, coinciding with the peak of bird migration through the area and the peak of bird song activity for most species as they establish territories on breeding grounds. This period of the year was considered to be the best time to sample bird density because they are more vocal when establishing territories and, hence, are more easily detected, and because the use of sites by spring migrants can also be evaluated. Data were summed over all census points for each census day and the average bird abundance derived from the average of the two census days in each year. Bird abundance was therefore expressed as mean abundance per sampling day per unit area. During the summer, another study examining mammal and herpetofaunal abundance allowed for additional presence/absence data to better estimate bird species richness during the growing season. Since the amount of time spent in each stand for all sampling activities (sampling of all wildlife groups) was approximately equivalent, bird species richness was derived from a list of all species heard or seen on the site throughout the entire sampling season, not just from those observed during point counts.

Habitat Sampling

Vegetation cover data were collected at 10 systematically random locations in each stand. Percentage overstory (>10 m tall) tree cover and midstory (2-10 m tall) cover were estimated using a transparent grid densiometer. Percentage shrub (0.5-2 m tall) cover and ground (<0.5 m tall) cover were estimated ocularly to the nearest 5% using a 1-m^2 sampling frame. At each sampling point, a prism count was conducted to estimate total live and dead (snag) tree basal area. Woody debris cover >5 cm in diameter was estimated using approximately ten 50-cm line-intercept transects within which the diameter of each woody debris item was measured. An index of woody debris was constructed using the sum of all woody debris diameters along transects.

Statistical Analyses

For species richness, species were counted if they were observed during formal sampling or if they were incidentally observed using the site during any visit to the site. The time spent on each site was roughly equivalent for all study sites allowing for comparisons of total species richness among sites. Analysis of variance was used to test the hypothesis of no difference between recently-logged and mature forest stands with respect to bird abundance or species

Table 1. Basal area and logging history of recently-logged and mature forest* stands in Franklin, Patrick, and Henry counties, Virginia.

Study Stand	Year of previous logging	Basal area $m^2 ha^{-1}$	Years sampled	Type of logging
Baker	2004	10.0	2005-6	Patch clearcutting/selective
Bowling	1960s	30.0	2004-6	Mature forest
Brubaker	2004	0.0	2005-6	Clearcut
Compton	2003	0.0	2004	Clearcut with site preparation
Ferrum Mtn.	1970s	24.5	2004-6	Mature forest
Ferrum Trail	1970s	26.5	2004-6	Mature forest
Ferrum Ridge	1970s	33.7	2004-6	Mature forest
Fredericksen	1960s	26.5	2004-6	Mature forest
Grice	2003	25.5	2004-6	Moderately selective
GT Lester	2003	2.7	2004-6	Heavy selective
Heck	1960s	36.2	2004-6	Mature forest
Hutchinson	1960s	30.0	2004	Mature forest
Kings Mountain	2003	5.0	2004-6	Heavy selective
Kitterman	1960s	40.0	2004-6	Mature forest
Naff	2003	23.8	2004-6	Moderately selective
Pettigo	1960s	32.2	2004-6	Mature forest
Potter	2002	17.0	2004	Moderately selective
Rocky Mt. 1	2003	16.5	2004-6	Heavy selective
Rocky Mt. 2	2004	10.0	2005-6	Heavy selective
Snow Creek	1960s	26.3	2004-6	Mature forest
Wagner	2003-4	12.0	2004-6	Heavy selective

*Indicates mature forest stand although light selective logging had occurred in some stands in the past (>30 years ago).

richness. Sampling year was included in the model. The natural logarithm of bird abundance was used because of unequal variances for bird abundance on recently-logged and mature forest stands. Pearson's correlation coefficient was used to test for the correlations between bird abundance and species richness with habitat variables. Differences were considered statistically different at $p \leq 0.05$, although p values ≤ 0.15 are reported to note trends towards statistical significance. Detrended correspondence analysis (DCA) was used to compare stands and stand-species associations with respect to bird species composition (PC-ORD, version 5, MJM software, Gleneden Beach, Oregon, USA).

RESULTS

Habitat Assessment

Recently-logged stands had nearly three times the percentage herbaceous layer cover and amount of large woody debris than mature forest stands (Table 2), while mature forest stands had three times the percentage overstory cover and twice the percentage midstory cover as logged stands. Percentage shrub cover and snag basal area were similar in logged and mature stands (Table 2).

Bird Abundance and Species Richness

A total of 79 bird species was observed on the study sites, of which 76 were observed in logged stands and 37 in mature stands. The Veery (*Catharus fuscescens*), Black-throated Blue Warbler (*Dendroica caerulescens*), and Rose-breasted Grosbeak (*Pheucticus ludovicianus*) were the only species found exclusively in mature forest stands. Logged stands had statistically higher mean bird abundance and species richness than mature forest stands despite the fact that two 1-year old clearcut stands had the lowest density and species richness of all stands during any given year (Fig. 1). Logged stands had approximately twice the mean bird abundance (5.79 ± 0.79) and 1.5X the species richness (21.79 ± 1.20), on average, than that of mature forest stands (abundance 2.83 ± 0.27; richness 15.24 ± 1.16) (Fig. 1). The Red-eyed Vireo (*Vireo olivaceus*) was, by far, the most common bird species observed in this study and occurred with almost identical abundance in both logged and mature forest stands (Table 3). The Scarlet Tanager (*Piranga olivacea*) and Tufted Titmouse (*Baeolophus bicolor*) were also commonly observed and had a similar abundance in both logged and mature forest stands (Table 3). These two were the only bird species observed in all 18 study stands during any given year.

Table 2. Mean percentage vegetation cover (± 1 standard error and range) at different forest layers, woody debris index, and snag basal area on recently-logged and mature forest stands in Franklin, Patrick, and Henry counties, Virginia.

Variable	Logged	Unlogged
Overstory cover (%)	27.0 ± 21.7 (0-55)	74.3 ± 15.0 (54-96)
Midstory cover (%)	35.0 ± 29.5 (0-84)	75.0 ± 12.1 (55-92)
Shrub layer cover (%)	28.0 ± 14.8 (7-53)	25.1 ± 16.4 (5-57)
Herbaceous layer cover (%)	51.3 ± 26.1 (13-78)	18.3 ± 11.5 (5-46)
Woody debris index	199.4 ± 51.1 (136-282)	68.2 ± 27.6 (18-107)
Snag basal area (m^2/ha)	0.16 ± 0.05 (0.05-0.45)	0.16 ± 0.02 (0.10-0.28)

Overstory cover included vegetation cover >10 m tall; midstory cover included vegetation cover >2 m tall and <10 m tall; shrub layer cover included vegetation cover >0.5 m tall and <2 m tall; herbaceous layer cover included vegetation cover <0.5 m tall. Means are presented with ± 1 standard deviation. Minimum and maximum values are included in parentheses.

Relatively common species with higher abundances on mature forest stands compared to logged stands included the Ovenbird (*Seiurus aurocapilla*), Wood Thrush (*Hylochicla mustelina*), and Acadian Flycatcher (*Empidonax virescens*). Other less abundant species showing a preference for mature stands included the Blue-headed Vireo (*Vireo solitarius*) and Yellow-billed Cuckoo (*Coccyzus erythropthalmus*).

A long list of species more common on logged sites compared to mature forest stands included American Redstart (*Setophaga ruticilla*), Mourning Dove (*Zenaida macroura*), Carolina Wren (*Thryothorus ludivicianus*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Yellow-throated Vireo (*Vireo flavifrons*), American Goldfinch (*Carduelis tristis*), Indigo Bunting (*Passerina cyanea*), Eastern Towhee (*Pipilio erythrophthalmus*), Yellow-breasted Chat (*Icteria virens*), Red-bellied Woodpecker (*Melanerpes carolinus*), Brown Thrasher (*Toxostoma rufum*), Gray Catbird (*Dumetella carolinensis*), Hooded Warbler (*Wilsonia citrina*), Kentucky Warbler (*Oporornis formosus*), Prairie Warbler (*Dendroica discolor*), and Chipping Sparrow (*Spizella passerina*) (Table 3).

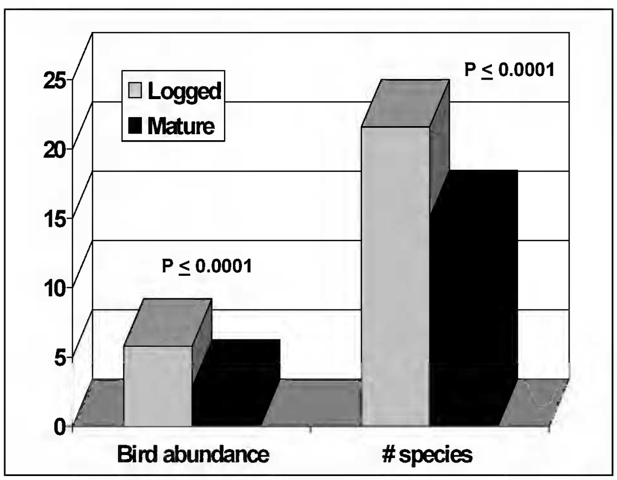

Fig. 1. Mean bird abundance (# birds/ha ± 1 standard error) and species richness (# bird species ± 1 standard error) on recently-logged and mature forest stands in Franklin, Patrick, and Henry counties, Virginia during 2004-2006.

DCA ordination axis 1 explained 51% of the variation in bird species composition among stands and axis 2 explained 23% of the variation. Recently logged stands were loaded on the right side of axis 1, with the most intensively logged stands appearing at the extreme end of the axis, and unlogged stands were clustered mostly to the left of axis 1 close to stands which had been partially cut (Fig. 2). Species on the ordination most closely placed with intensively logged stands included early-successional species such as Indigo Bunting, American Goldfinch, Prairie Warbler, and Gray Catbird. Bird species most closely associated with the left side of axis 1 included those typical of mature forests, such as Yellow-billed Cuckoo, Ovenbird, Acadian Flycatcher, Wood Thrush, and Blue-headed Vireo. Axis 2 is more difficult to interpret, although it may have been related to habitat patchiness, because two lightly selectively logged stands with a large amount of residual basal area interspersed with canopy gaps were isolated at the upper end of this axis (Fig. 2). Species most closely associated with these stands included Kentucky Warbler, American Redstart, Hooded Warbler, and White-breasted Nuthatch.

Relation of Bird Abundance and Species Richness to Habitat Variables

Bird species abundance was negatively correlated to overstory tree cover (Fig. 3) and midstory tree cover and positively correlated to herbaceous layer cover and large woody debris (Table 4). Bird species abundance was not significantly correlated with shrub cover. Relationships for species richness were similar except that species richness was not significantly correlated with overstory cover (Table 4). Similar results were obtained by using correlations of habitat variables with DCA ordination axes. DCA axis 1 was significantly and

Table 3. Mean bird density (# birds/ha ± 1 standard error) of bird species observed during point counts in recently-logged and mature forest stands in Franklin, Patrick, and Henry counties, Virginia during 2004-2006. An asterisk (*) indicates that species were observed on unlogged or logged stands at some point during the study although they were not detected during point counts.

Species	Mature forest	Recently-logged
Wild Turkey (*Meleagris gallopavo*)	0.02 (0.02)	0.02 (0.02)
Accipiter Species (*Accipiter* sp.)	0.00 (0.00)	0.00 (0.00)*
Northern Harrier (*Circus cyaneus*)	0.00 (0.00)	0.00 (0.00)*
Red-shouldered Hawk (*Buteo lineatus*)	0.00 (0.00)	0.00 (0.00)*
Broad-winged Hawk (*Buteo playpterus*)	0.00 (0.00)	0.00 (0.00)*
Red-tailed Hawk (*Buteo jamaicensis*)	0.00 (0.00)	0.02 (0.01)
Mourning Dove (*Zenaida macroura*)	0.00 (0.00)	0.06 (0.05)
Yellow-billed Cuckoo (*Coccyzus americanus*)	0.03 (0.03)	0.00 (0.00)*
Black-billed Cuckoo (*Coccyzus erythropthalmus*)	0.00 (0.00)	0.00 (0.00)*
Ruby-throated Hummingbird (*Archilocus colubris*)	0.01 (0.01)	0.02 (0.01)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	0.00 (0.00)	0.00 (0.00)*
Red-bellied Woodpecker (*Melanerpes carolinus*)	0.03 (0.03)	0.12 (0.05)
Pileated Woodpecker (*Dryocopus pileatus*)	0.01 (0.01)	0.00 (0.00)*
Northern Flicker (*Colaptes auratus*)	0.01 (0.01)	0.03 (0.03)
Downy Woodpecker (*Picoides pubescens*)	0.05 (0.03)	0.04 (0.01)
Hairy Woodpecker (*Picoides villosus*)	0.02 (0.01)	0.03 (0.02)
Eastern Kingbird (*Tyrannus tyrannus*)	0.00 (0.00)	0.00 (0.00)*
Great-crested Flycatcher (*Myiarchus crinitus*)	0.02 (0.02)	0.02 (0.01)
Eastern Phoebe (*Sayornis phoebe*)	0.01 (0.01)	0.05 (0.03)
Eastern Wood-Pewee (*Contopus virens*)	0.00 (0.00)*	0.04 (0.02)
Least Flycatcher (*Empidonax minimus*)	0.00 (0.00)	0.00 (0.00)*
Acadian Flycatcher (*Empidonax virescens*)	0.10 (0.05)	0.04 (0.04)
Willow Flycatcher (*Empidonax traillii*)	0.00 (0.00)	0.00 (0.00)*
American Crow (*Corvus brachyrhynchos*)	0.05 (0.03)	0.00 (0.00)*
Blue Jay (*Cyanocitta cristata*)	0.07 (0.03)	0.05 (0.02)
Carolina Chickadee (*Poecile carolinensis*)	0.07 (0.04)	0.11 (0.03)
Tufted Titmouse (*Baeolophus bicolor*)	0.17 (0.05)	0.18 (0.05)
White-breasted Nuthatch (*Sitta carolinensis*)	0.07 (0.03)	0.08 (0.05)
House Wren (*Troglodytes aedon*)	0.00 (0.00)	0.00 (0.00)*
Carolina Wren (*Thryothorus ludovicianus*)	0.05 (0.02)	0.13 (0.03)
Ruby-crowned Kinglet (*Regulus calendula*)	0.00 (0.00)	0.00 (0.00)*
Blue-gray Gnatcatcher (*Polioptila caerulea*)	0.01 (0.01)	0.16 (0.05)
Brown Thrasher (*Toxostoma rufum*)	0.01 (0.01)	0.08 (0.06)
Gray Catbird (*Dumetella carolinensis*)	0.00 (0.00)	0.07 (0.04)
Eastern Bluebird (*Sialis sialis*)	0.00 (0.00)	0.02 (0.02)
American Robin (*Turdus migratorius*)	0.00 (0.00)	0.01 (0.01)
Wood Thrush (*Hylocichla mustelina*)	0.26 (0.06)	0.12 (0.04)
Veery (*Catharus fuscescens*)	0.00 (0.00)*	0.00 (0.00)
Cedar Waxwing (*Bombycilla cedrorum*)	0.00 (0.00)	0.00 (0.00)*
Red-eyed Vireo (*Vireo olivaceus*)	0.86 (0.11)	0.85 (0.18)
Yellow-throated Vireo (*Vireo flavifrons*)	0.01 (0.01)	0.10 (0.06)
White-eyed Vireo (*Vireo griseus*)	0.00 (0.00)	0.05 (0.03)
Blue-headed Vireo (*Vireo solitarius*)	0.07 (0.05)	0.03 (0.02)
Warbling Vireo (*Vireo gilvus*)	0.00 (0.00)	0.00 (0.00)*
Black-and-white Warbler (*Mniotilta varia*)	0.02 (0.02)	0.03 (0.01)
Black-throated Blue Warbler (*Dendroica caerulescens*)	0.01 (0.01)	0.00 (0.00)
Yellow-rumped Warbler (*Dendroica coronata*)	0.06 (0.04)	0.10 (0.06)
Chestnut-sided Warbler (*Dendroica pensylvanica*)	0.00 (0.00)	0.00 (0.00)*
Pine Warbler (*Dendroica pinus*)	0.00 (0.00)	0.02 (0.02)
Prairie Warbler (*Dendroica discolor*)	0.00 (0.00)	0.06 (0.04)
Palm Warbler (*Dendroica palmarum*)	0.00 (0.00)	0.02 (0.02)
Yellow Warbler (*Dendroica petechia*)	0.00 (0.00)	0.00 (0.00)*
American Redstart (*Setophaga ruticilla*)	0.01 (0.01)	0.40 (0.23)
Blue-winged Warbler (*Vermivora pinus*)	0.00 (0.00)	0.00 (0.00)*
Worm-eating Warbler (*Helmintheros vermivorus*)	0.02 (0.01)	0.01 (0.01)
Canada Warbler (*Wilsonia canadensis*)	0.00 (0.00)	0.00 (0.00)*
Hooded Warbler (*Wilsonia citrina*)	0.06 (0.02)	0.12 (0.04)
Kentucky Warbler (*Oporornis formosus*)	0.00 (0.00)*	0.09 (0.05)
Common Yellowthroat (*Geothlypis trichas*)	0.00 (0.00)	0.02 (0.02)
Yellow-breasted Chat (*Icteria virens*)	0.00 (0.00)	0.22 (0.13)
Northern Waterthrush (*Seiurus noveboracensis*)	0.00 (0.00)	0.00 (0.00)*
Louisiana Waterthrush (*Seiurus motacilla*)	0.00 (0.00)	0.01 (0.01)
Ovenbird (*Seiurus aurocapilla*)	0.25 (0.07)	0.12 (0.09)
Brown-headed Cowbird (*Molothrus ater*)	0.00 (0.00)	0.03 (0.01)
Common Grackle (*Quiscalus quiscala*)	0.00 (0.00)	0.00 (0.00)
Orchard Oriole (*Icterus spurius*)	0.00 (0.00)	0.03 (0.01)
Baltimore Oriole (*Icterus glabula*)	0.00 (0.00)	0.00 (0.00)*
Summer Tanager (*Piranga rubra*)	0.00 (0.00)	0.00 (0.00)*
Scarlet Tanager (*Piranga olivacea*)	0.21 (0.09)	0.19 (0.10)
Northern Cardinal (*Cardinalis cardinalis*)	0.09 (0.03)	0.36 (0.14)
American Goldfinch (*Carduelis tristis*)	0.00 0.00)	0.28 (0.09)
Blue Grosbeak (*Guiraca caerulea*)	0.00 (0.00)	0.00 (0.00)*
Indigo Bunting (*Passerina cyanea*)	0.00 (0.00)*	0.38 (0.11)
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	0.03 (0.03)	0.00 (0.00)
Eastern Towhee (*Pipilo erythrophthalmus*)	0.00 (0.00)*	0.33 (0.10)
White-throated Sparrow (*Zonotrichia albicollis*)	0.00 (0.00)	0.00 (0.00)*
Chipping Sparrow (*Spizella passerina*)	0.00 (0.00)	0.10 (0.07)
Field Sparrow (*Spizella pusilla*)	0.00 (0.00)	0.03 (0.02)
Song Sparrow (*Melospiza melodia*)	0.00 (0.00)	0.02 (0.02)
Unidentified Birds	0.12 (0.04)	0.31 (0.10)

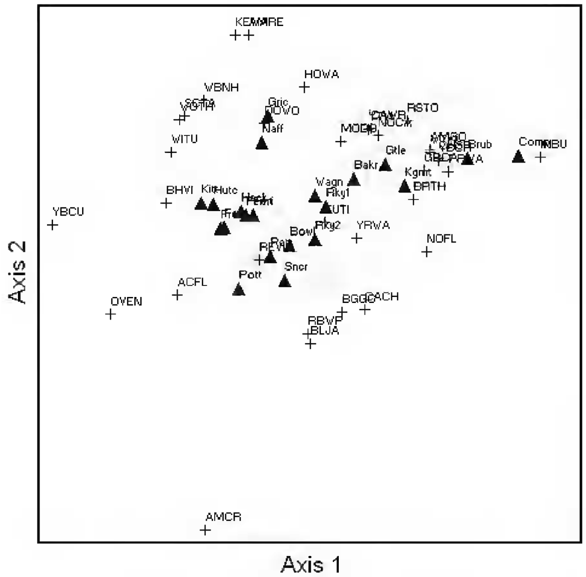

Fig. 2. Detrended correspondence analysis (DCA) ordination of bird species abundance on recently-logged and mature forest stands in Franklin, Patrick, and Henry counties, Virginia during 2004-2006. Solid triangles represent study stands and crosses represent species.

negatively related to percent overstory cover (r = -0.85, p < 0.0001) and percent midstory cover (r = -0.80, p < 0.0001) and positively correlated with percentage herbaceous layer cover (r = 0.73, p = 0.001) and amount of coarse woody debris (r = 0.48, p = 0.04). The most closely correlated habitat variables with DCA axis 2 were percent herbaceous layer cover (r = 0.66, p = 0.003) and coarse woody debris (r = 0.63, p = 0.005) (Fig. 2).

DISCUSSION

Logged stands had approximately twice the bird abundance and 50% higher species richness than mature forest stands. Several studies have documented high bird species abundance and species richness in early-successional forest habitats or higher species diversity in gaps, often as a result of logging (Chadwick et al., 1986; Welsh & Healy, 1993; Hagan et al., 1995; Greenberg & Lanham, 2001; Ross et al., 2002). Logging creates increased light to the forest floor, increasing the growth of plants and creating an increase in structural diversity in the understory. Along with increased woody debris created by logging, increased structural diversity in the vegetation provides more feeding and breeding habitat for many species of birds (Balda, 1975; Yahner & Smith, 1990; Greenberg & Lanham, 2001).

Table 4. Pearson's Correlation of bird species abundance and species richness with habitat variables in recently-logged and mature forest non-industrial private forestlands in Franklin, Patrick, and Henry counties, Virginia.

Variable	Bird Abundance		Species Richness	
	r	p	r	p
Overstory cover (%)	- 0.50	0.03	- 0.34	0.17
Midstory cover (%)	- 0.56	0.02	- 0.47	0.05
Herbaceous cover (%)	0.67	0.002	0.63	0.006
Shrub cover (%)	0.38	0.12	0.38	0.40
Woody debris index	0.81	≤0.0001	0.81	≤0.0001
Snag basal area	0.16	0.76	0.08	0.52

Bird species abundance and species richness increased with logging intensity in this study except for two very recent clearcuts. One of these clearcuts had been site-prepared and had very little vegetation and coarse woody debris had been skidded into large piles. Unfortunately, that stand was excluded from the study in 2005 because the owner decided to build a home on the property and it was replaced by a second clearcut in 2005. The replacement stand was completely clearcut in the Fall of 2004 with no trees >10 cm dbh remaining. In 2005, it had a very low bird abundance and species richness. However, in 2006, vegetation had recovered to the point where bird abundance and species richness were similar to the mean for all logged sites. The DCA ordination placed both of these stands at the extreme right of axis 1.

Similar to this study, Hagan et al. (1995) found that clearcuts initially have very low bird diversity. A large number of early successional bird species, however, appear to quickly colonize clearcut stands, which are otherwise rarely found in selectively logged or unlogged stands. In this study, these species included Chipping Sparrow, Yellow-breasted Chat, Field Sparrow (*Spizella pusilla*), Song Sparrow (*Melospiza melodia*), Eastern Bluebird (*Sialis sialis*), Prairie Warbler, White-eyed Vireo (*Vireo griseus*), Gray Catbird, Brown Thrasher, Indigo Bunting, Common Yellowthroat (*Geothylpis trichas*), American Goldfinch, and Eastern Towhee. Many of these species have been found to be area-sensitive shrubland birds that avoid edges (Rodewald & Vitz, 2005).

Some bird species in this study responded positively to logging, but tended to be most abundant in stands that were not intensively logged. These species included the Hooded Warbler, Kentucky Warbler, and the American Redstart, all of which breed in the study area. The DCA ordination placed these species at the upper terminus of axis 2. The Hooded Warbler has been described as a gap associate species (Greenberg & Lanham, 2001) and the American Redstart has also been associated with forest clearings (Yahner & Smith,

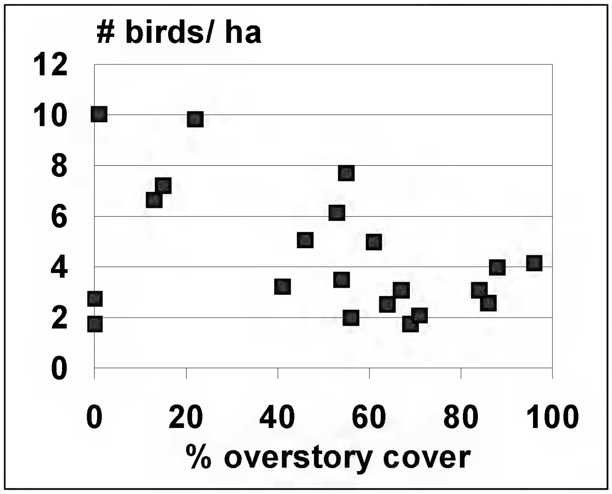

Fig. 3. Relationship between bird abundance and percentage overstory cover on recently-logged and mature forest stands in Franklin, Patrick, and Henry counties, Virginia during 2004-2006. The two stands at the bottom left of the chart are recent (<1 year-old) clearcut stands.

1990). While common in intensively logged stands as well, other species occurred commonly in selectively logged forest, including the Carolina Wren, Northern Cardinal, Blue-gray Gnatcatcher, and Yellow-throated Vireo. Interestingly, the Red-bellied Woodpecker (*Melanerpes carolinus*) was four times more abundant in logged stands compared to mature forest stands, although the abundances of both Downy (*Picoides pubscens*) and Hairy Woodpeckers (*P. villosus*) were similar among logged and mature forest stands.

As expected, Ovenbird and Wood Thrush were much more abundant on mature forest stands than logged stands and rarely occurred in intensively cut stands. Both of these species have been described as forest interior species (Ehrlich et al., 1988). Blue-headed Vireo and Acadian Flycatcher were also more common in mature stands than logged stands, but they did occur in some selectively logged stands. Interestingly, other birds considered to be forest interior species, including Scarlet Tanager and Red-eyed Vireo, had similar abundances on logged and mature forest stands. These species were even retained on intensively logged stands provided that there were small patches of mature trees left within the stand, such as along riparian areas.

Bird species abundance was negatively correlated with overstory tree cover and midstory tree cover and positively correlated with herbaceous layer cover and coarse woody debris. It is difficult to determine the relative importance of these relationships for habitat quality, however, because they are autocorrelated to some degree. Logging decreases overstory cover, thereby increasing light availability to the forest floor, which stimulates the growth of understory cover. The upper portions of trees and non-merchantable trees that are felled or toppled during the logging operation increase coarse woody debris on the forest floor, unless they are chipped, burned or otherwise disposed of following logging. Removal of woody debris occurred on only one stand in this study. Herbaceous layer cover and woody debris provide foraging habitat and cover for many species of birds (Titterington et al., 1979; Hagan et al., 1995).

It is not intuitively clear why midstory tree cover would be negatively correlated with bird abundance or species richness. Many intensively logged stands result in low overstory tree cover, but relatively high midstory cover. The retention of these trees may also provide perching, singing, cover, and foraging habitat for birds. On the other hand, an abundance of midstory cover may suppress herbaceous layer cover, which appears to be important for many bird species. It is also interesting that shrub layer cover was not correlated with bird abundance or species richness in this study given that many shrub and tree species respond positively to increased light availability following logging (Carter & Fredericksen 2007). Many unlogged stands in this study, however, had areas with relatively dense shrub cover consisting of Mountain Laurel (*Kalmia latifolia*) and Rhododendron (*Rhododendron* spp.).

There was little correlation between snag basal area and bird abundance or species richness in this study despite the fact that many studies find snag tree retention to be critical for retaining bird species richness in logged stands (Sallabanks & Arnett, 2005). I have personally observed, however, that loggers in the study area do not purposely fell snags, or other non-merchantable stems, although they may be toppled inadvertently by falling trees or logging machinery. Any loss of snag basal area due to toppling during the logging operation may perhaps be offset by the fact that some snags are likely to be created during logging due to root damage or other injuries to live trees. Indeed, mean snag basal area was identical in logged and mature forest stands (Table 2).

It is important to note several limitations of this study. First, the study only addressed bird species abundance during the early breeding season. Studies have documented habitat shifts during the breeding season for birds, particularly the use by fledglings of areas with dense vegetation, such as those created by logging, for bird species that tend to nest in mature forest (Anders et al., 1998; Vega Rivera et al., 1998; Marshall et al., 2003; King et al., 2006; Vitz & Rodewald, 2006). The impact on wintering habitat is also unknown. The timing of this study also coincided with spring migration during which birds are less selective of habitat or perhaps use different habitats than they do during the breeding season. Finally, this study did not document bird productivity differences due to logging or the intensity of logging. The presence of a bird species on a site does not indicate that it is also reproductively successful on that site (Brawn & Robinson, 1996), although studies have documented increases in bird productivity following logging in eastern forests (Ross et al., 2001; Weakland et al., 2002). Despite these limitations, this study is one of only a very few studies documenting the relative abundance, species richness, and composition of bird communities on recently-logged or mature non-industrial private forestlands.

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LITERATURE CITED

Anders, A. D., J. Faaborg, & F. R. Thompson. 1998. Postfledgling dispersal, habitat use, and home-range size of juvenile wood thrushes. Auk 115: 349-358.

Balda, R. P. 1975. Vegetation structure and breeding bird diversity. Pp. 59-80 *In* D. R. Smith (ed.), Symposium of Forest and Range Habitats for Non-game Birds. USDA Forest Service General Technical Report WO-1. Tucson, AZ.

Best C., & L. A. Wayburn. 2001. America's Private Forests: Status and Stewardship. Island Press, Washington, DC. 268 pp.

Birch, T.W. 1996. Private forest landowners of the United States, 1994. Resource Bulletin NE-134. USDA Forest Service Northeastern Forest Experiment Station, Radnor, PA. 183 pp.

Brawn, J. D., & S. K. Robinson. 1996. Source-sink population dynamics may complicate the interpretation of long-term census data. Ecology 77: 3-12.

Brawn, J. D., S. K. Robinson, & F. R. Thompson. 2001. The role of disturbance in the ecology and conservation of birds. Annual Review of Ecology and Systematics 32: 251-276.

Butler, B. J., & E. C. Leatherberry. 2004. America's family forest owners. Journal of Forestry 102: 4-9.

Carter, W. K., & T. S. Fredericksen. 2007. Tree seedling and sapling density and deer browsing incidence on recently-logged and mature non-industrial private forestlands in Virginia, USA. Forest Ecology and Management 242: 671-677.

Chadwick, N. L., D. R. Progaluski, & J. T. Finn. 1986. Effects of fuelwood cutting on birds in southern New England. Journal of Wildlife Management 50: 398-405.

Crawford, H. S., R. G. Hooper, & R. W. Titterington. 1981. Songbird population response to silvicultural practices in central Appalachian hardwoods. Journal of Wildlife Management 45: 680-692.

DeGraaf, R. M. 1991. Breeding bird assemblages in managed northern hardwood forests in New England. Pp. 153-171 *In* J. E. Rodick & E. G. Bolen (eds.), Wildlife and Habitats in Managed Landscapes. Island Press, New York.

Dettmers, R. 2003. Status and conservation of shrubland birds in the northeastern U.S. Forest Ecology and Management 185: 81-93.

Ehrlich, P. R., D. S. Dobkin, & D. Wheye. 1988. The Birder's Handbook. Simon and Shuster Inc., New York, NY. 785 pp.

Fredericksen, T. S., B. D. Ross, W. H. Hoffman, E. Ross, M. L. Morrison, J. Beyea, M. L. Lester, & B. N. Johnson. 2000. The impact of logging on wildlife: a study in northeastern Pennsylvania. Journal of Forestry 98: 4-10.

Greenberg, C. H., & J. D. Lanham. 2001. Breeding bird assemblages of hurricane-created gaps and adjacent closed canopy forest in the southern Appalachians. Forest Ecology and Management 154: 251-260.

Hagan, J. M., P. S. McKinley, A. L. Meehan, & S. L. Grove. 1997. Diversity and abundance of landbirds in a northeastern industrial forest landscape. Journal of Wildlife Management 61: 718-735.

Jones, S. B, A. E. Luloff, & J. C. Finley. 1995. Another look at NIPFs: facing our "myths". Journal of Forestry 93: 41-44.

King, D. I., R. M. DeGraaf, M. L. Smith, & J. P. Buonaccorsi. 2006. Habitat selection and habitat-specific survival of fledgling ovenbirds (*Seiurus aurocapilla*). Journal of Zoology 269: 414-421.

Marshall, M. R., J. A. DeCocco, A. B.Williams, & G. A. Gale. 2003. Use of regenerating clearcuts by late-successional bird species and their young during the post-fledgling period. Forest Ecology and Management 183: 127-135.

Peterjohn, B. G., J. R. Sauer, & C. S. Robbins. 1995. Population trends from the North American Breeding Bird Survey. Pp. 3-39 *In* T. E. Martin & D. M. Finch (eds.), Ecology and Management of Neotropical Migratory Birds: A Synthesis and Review of Critical Issues. Oxford University Press, New York.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, & S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Sciences 86: 7658-7662.

Robinson, W. D., & S. K. Robinson. 1999. Effects of selective logging on forest bird populations in a fragmented landscape. Conservation Biology 13: 58-66.

Rodewald, A. D., & A. C. Vitz. 2005. Edge- and area-sensitivity of shrubland birds. Journal of Wildlife Management 69: 681-688.

Ross, B. D., M. L. Morrison, W. Hoffman, T. S. Fredericksen, R. J. Sawicki, E. Ross, M. L. Lester, J. Beyea, & B. N. Johnson. 2001. Bird relationships to habitat characteristics created by timber harvesting in Pennsylvania. Journal of the Pennsylvania Academy of Sciences 74: 71-84.

Sallabanks, R., & E. B. Arnett. 2005. Accommodating birds in managed forests of North America: A review of bird-forestry relationships. USDA Forest Service General Technical Report PSW-GTR-191. Albany, CA. 28 pp.

Sauer, J. R., J. E. Hines, & J. Fallon. 2005. The North American Breeding Bird Survey, Results and Analysis 1966-2005. Version 6.2.2006. http://www.mbr-pwrc.usgs.gov/bbs/bbs2005.html United States Geological Survey, Patuxent Wildlife Research Center, Laurel, MD.

Thompson, M. T., & T. G. Johnson. 1996. A forested tract-size profile of Virginia's NIPF landowners. Research Paper SRS-1, USDA Forest Service Southern Forest Research Station. Asheville, NC. 8 pp.

Titterington, R., H. Crawford, & B. Burgason. 1979. Songbird responses to commercial clearcutting in Maine spruce-fir forests. Journal of Wildlife Management 43: 602-609.

Vega Rivera, J. H., J. H. Rappole, W. J. McShea, & C. A. Haas. 1998. Wood thrush postfledgling movements and habitat use in northern Virginia. Condor 100: 69-78.

Vitz, A. C., & A. D. Rodewald. 2006. Can regenerating clearcuts benefit mature-forest songbirds? Biological Conservation 127: 477-486.

Weakland, C. A., P. B. Wood, & W. M. Ford. 2002. Responses of songbirds to diameter-limit cutting in the central Appalachians of West Virginia, USA. Forest Ecology and Management 155: 115-129.

Welsh, C. J., & W. M. Healy. 1993. Effects of even-aged timber management on bird species diversity and composition in northern hardwoods of New Hampshire. Wildlife Society Bulletin 21: 143-154.

Yahner, R. H., & H. R. Smith. 1990. Avian community structure and habitat relationships in Central Pennsylvania forests. Journal of the Pennsylvania Academy of Sciences 64: 3-7.